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make discrimination more accurate for it than for the other. Each color was compared only with its own next neighbor in the series whereas each odor was compared with every other odor in the same group. In a certain proportion of the comparisons, the same color or odor was repeated. The interval between the stimuli compared was one minute *minus* the seconds of the first exposure-time, namely, ten seconds for the odors, five seconds for the colored papers and two seconds for the colored liquids. The subjects were all under-graduates, three or four in number for each two sets of comparable stimuli. Each observer made at least one hundred comparisons within each set of stimuli.

A comparison of the number of errors for the named and for the unnamed stimuli shows that a scheme of names was of slight assistance to three-fifths of our subjects in qualitative discrimination, but that the advantage was trifling, not a gain of 5% of right cases for the named series. An examination, however, of the direction of errors so appertained shows that at least, in the case of the colors the name-images aided only in discrimination proper, and actually increased the number of failures to identify. When the stimulus was repeated the percentage of wrong cases in the named series exceeded by ten the percentage in the unnamed series. Thus, it would appear that in so far as recognition is equivalent to the consciousness of sameness, associations artificially provided in the form of verbal tags tend rather to inhibit than to facilitate its occurrence. The result, therefore, of the investigation as a whole is to discount the value of supplementary associations both in recognition and in comparison.

ELEANOR A. MCC. GAMBLE.

On the Validity of the Ergograph as a Measure of Work Capacity. A Contribution to Practice and Learning, by T. L. BOLTON and ELEANORA T. MILLER. Nebraska University Studies, Lincoln, 1904, pp. 79-128.

This article gives the results of an experimental study with the ergograph, with the object of determining the value of ergograph records as an accurate measure of work capacity. A detailed analysis of the various factors that enter in determining the ergograph results furnishes the basis for such determination. Thus directed, the study gives results of psychological interest beyond that of merely determining the value of an apparatus. Some general observations on the factors in muscular training, and 'physiological considerations' are first briefly reviewed. Their object then becomes that of a scientific study of these supposed factors. The authors were the two subjects in the experiment, which extended over three months. A procedure similar to the usual inergograph work was followed. "The ergograph used was a modified form of the pattern designed by Dr. Hoch in Kraepelin's laboratory." A plate, with description, gives the details of the apparatus. Introspective results supplement and interpret the eight full tables given. Four elements in practice gain are first pointed out and described. *First*, inurement, 'a process of hardening and toughening of the skin where it comes in contact with the apparatus, and of habituating the muscles to the strains which the unusual effort imposes.' The severe strain the authors regard as causing 'small lesions of the tissues through the rubbing and twisting of muscular and tendonal fibres about one another which are followed by local inflammations.' This inurement appears rapidly, and is completed before any of the other effects of practice. It is also the first to disappear when work ceases. *Second*, perfection in the co-ordination of movements. At first there are various accessory and useless movements, muscles in the other fingers of the hand, and various other muscles over the whole body being involved

in the strain of maximum effort. These drop out later, and a condition is finally attained in which 'the actual exhaustion point is reached without visible physical or mental signs of fatigue, and it seems to avail nothing to put effort into it.' *Third*, increase in the ability to make the movements rhythmically. Between the metronome beats each part of the movement, together with other stimuli from the apparatus, must be the stimulus for the next part, separated by a time interval that is practically equal to the full reflex time of such act. The whole must become 'a series of reflex actions joined together in a serial order by habit.' *Fourth*, endurance. This is interpreted as an 'increase in the power of the nerve centre to excite a muscle to perform a certain work a greater number of times than it could before the exercise.' Of the four elements in practice gain enumerated, this one is acquired more slowly. The working of these four factors, and their inter-relations in affecting the work capacity are then further traced out in the results. After three rest periods of six days each the work capacity begins each time at a point above that at which it stood when the rest period began. This they attribute to the last factor, accounting for it by the supposition that 'the nerve centres and muscles were in a state of incipient exhaustion, and that during the rest period they built themselves up to the highest level of metabolic change for which they had been prepared by the exercise.' A very large vicarious practice effect is found, when one hand is given a rest period while work with the other continues, and this in spite of the loss of inurement during the rest period for the unused hand. This vicarious practice they regard as mostly in the direction of co-ordination and rhythm. The records for the right and left hands also show certain differences in the progress of practice gain, indicating that the different elements in practice gain may enter in different relations for different muscles. 'Different muscles in the same person seem to show idiosyncracies in the way they work. What one accomplishes in the way of skill another makes up through endurance.' From all these relations it happens that the hand that shows the greater practice gain at first may not do so later, and the order of the two hands may alternate more than once. Again, lack of inurement at first keeps the record down. As this lack diminishes the practice gain will be great, and later it will be less, due to a change again in the relation of the factors that enter. In a daily series of several contractions to exhaustion with one minute pauses between, the recuperative value of the pauses may be different for the two hands; it changes with the degree of practice attained, as does also the relative recuperative value of the successive minute pauses. Hence, in regard to the value of the ergograph as a means of measuring work capacity, the authors conclude that 'ergograph records change relatively in the course of a long series and thus the first records in a series are invalidated, for maximum performances furnish a more reliable measure of work capacity. That since exercise induces a condition within the muscles themselves which reduces their capacity for work, ergograph records have slight validity until inurement has become thorough and co-ordination complete. That the ergograph is quite unadapted to the obtaining of exact statistics upon a large number of individuals. That records taken upon unpracticed subjects, both before and after operations, whose influences are thought to affect muscular power, are without the slightest claim to trustworthiness.'

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The Principles of Logic. PROFESSOR H. AUSTIN AIKINS, Western Reserve University. New York, Holt & Co. pp. x+489.

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